Micro-fluoresence Studies of Selective Area Growth InGaAsP thin films

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Beamline(s): **X13**

Introduction: Selective Area Growth (SAG) of quaternary InGaAsP compounds is accomplished by patterning the InP substrate with an oxide mask and then growing a quaternary layer in an MOCVD reaction chamber exactly as one would for an un-patterned film. The metallo-organic growth precursors (e.g., Trimethyl-Gallium) will not stick to the oxide surface, leading to local variations of the reactant concentrations near the growing surface. For each element there is a length scale over which the local concentrations of the 4 elements vary, i.e. an effective diffusion length for each element. For example these effective diffusion lengths are typically 30 microns for indium, and for Ga 200 microns. The patterning thus perturbs the local growth rate and composition of the quaternary material, resulting in a strain, thickness and band-gap variation with position.

A model for SAG has been developed. To test the model, a test structure consisting of pairs of oxide pads of different pad widths, separated by different gap widths was studied. One needs spatially resolved strain, thickness and composition to compare with the model.

Methods and Materials: The experiment was performed at the X13B insertion device beamline using the In-vacuum small-gap undulator (IVUN) around the second-harmonic, together with a double-crystal Si(111) channel-cut monochromator. The micro-focus was provided by a pair of gold differentially deposited mirrors in the Kirpatrick-Baez geometry which produced a beam of ~ 5x10 microns and a flux of ~ 10^8 ph/sec.

Results: Shown in Figure 1 is the raw fluorescence for Ga as a function of position. One clearly observes the enhancement in the vicinity of the pair of oxide pads, and the two strong dips in signal at the location of the pads. Since the signal is proportional to the local thickness of the film and the local concentration, one needs to divide by the thickness of the film. The film thickness is measured only at the mid-point between two pads, and is measured on beamline X16C. This is combined with the fluorescence signal from the mid-point of a similar figure to Figure 1 but for Ga fluorescence. In Figure 2 we show the enhancement of Ga signal as a function of pad width for a constant gap width of 20 microns. A pad width of zero corresponds to a point far away from all pads, i.e. many effective diffusion lengths away.

Conclusions: Using synchrotron based micro-fluorescence, we are able to extract the local enhancement of Ga and As on quaternary InGaAsP films.

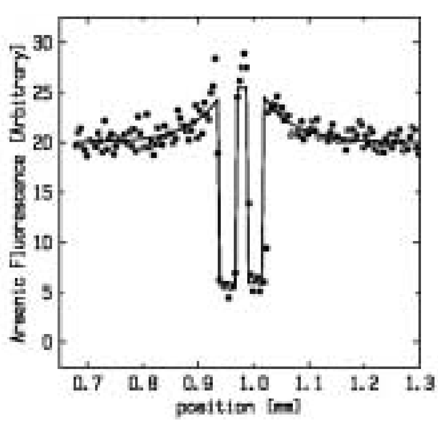

Figure 1. Raw Arsenic fluorescence signal.

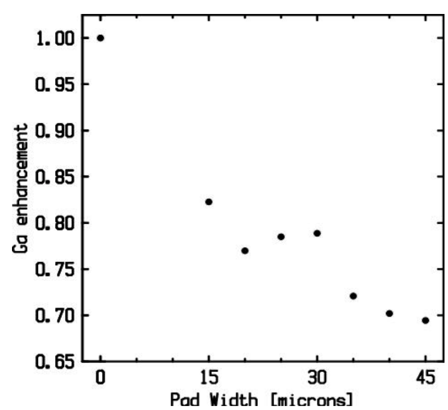

Figure 2. The Ga enhancement relative to the field value.